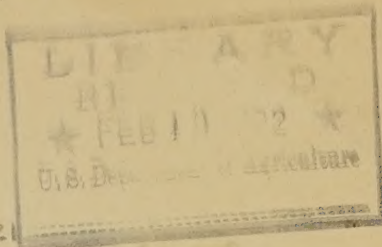


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RESEARCH IN AGRICULTURAL ENGINEERING *



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In this report an attempt has been made to summarize the outstanding features of agricultural engineering experimentation, investigation, and research completed or in progress during the past year at the State Agricultural experiment stations, certain other State and Federal institutions, and certain foreign agricultural and engineering institutions. From this summary and from the survey work of the Research Committee during the year, attempts have also been made to draw attention to certain desirable lines along which it is believed agricultural engineering studies should proceed.

Unfortunately certain factors enter into the preparation of such a report which tend to result in the omission of numerous important features and to make absolute accuracy in the statement of certain others quite difficult to attain. This is especially true of cooperative projects where the work has been reported under some department of the station other than the Agricultural Engineering Department. Again many projects are being conducted wholly on State funds and may be omitted from reports to the Office of Experiment Stations. Furthermore, it has been found very difficult in a number of cases to obtain complete or comprehensive statements from the officials of State institutions. All in all, numerous omissions and inaccuracies undoubtedly occur in this report. In view of the difficulties incident to its preparation, however, it is hoped that they will be in a measure overlooked, but that efforts will be made in all cases by the people concerned to assist in their correction.

What appears to be an unfortunate feature of the work in agricultural engineering at the stations this year, as in previous years, is the fact that much of it has been done in departments other than the Agricultural Engineering Department. Obviously, to obtain the best results, such work should be done at least in cooperation with the Agricultural Engineering Department. Again, the total lack or only partial appreciation of the research or the truly investigational viewpoint is still evident in too many cases. This is unfortunate, but it is believed that this attitude is not so prevalent as in previous years. In fact, in many quarters there is evidence of a strongly growing interest in research and scientific investigation, and it is believed from the correspondence received during the year by the Research Committee that this interest is rapidly spreading.

The work in agricultural engineering during the year included the following general subjects: Farm machinery, farm buildings, drainage, irrigation, farm water supply and sewage disposal, land clearing, materials of construction, and miscellaneous.

* Partial report of the Chairman of the Research and Data Committee, American Society of Agricultural Engineers.

FARM MACHINERY

One of the more important features of the farm machinery studies during the year seems to have been the work relating to tractors, of which tractor economics comprised a considerable portion. Economic studies were reported from the Illinois, Indiana, Florida, Missouri, Connecticut, Montana, and New York Cornell Stations. In most cases these studies were conducted on State funds and, with one or two exceptions, were handled by departments other than the Agricultural Engineering Department. In view of the fact that somewhat over 300 different types of tractor are being manufactured and sold in this country today, the question constantly arises as to what of permanent value to agricultural engineers actually results from an analysis of the purely statistical data obtained.

It is believed that this argues the importance of conducting such studies at least on a cooperative basis with agricultural engineers in order that they may be planned and carried out and the results analyzed, with a view to producing basic information of both practical and scientific value. It is to be noted in this connection that the tractor economics studies of the U. S. Department of Agriculture have apparently been placed on such a cooperative basis. These studies, if properly planned and carried out, should yield considerable information upon which to base engineering projects in tractor research.

There seems to be a tendency in the tractor work at some of the stations to formulate what appear to be blanket projects covering a multitude of problems. Of course, conditions and circumstances often influence such cases but nevertheless there is a strong indication of a lack of appreciation of the magnitude of the problem and of the importance of selective judgment in its treatment. A broad subject like tractors which includes a large number of unsolved problems can not possibly be given comprehensive treatment in one project without a very large personnel and extensive equipment. It would seem better, therefore, to analyze the subject into its important elements and select the most pressing problem, with reference to locality and conditions, for first treatment. The work on this problem should be planned with a certain definite object in view calculated to tie it up with the other tractor problems. Definite provision for funds and personnel should be made to see this particular step through to completion.

As instances of the growing tendency to exercise analytical and selective judgment in dealing with the tractor problem, attention may well be drawn to the work at the Indiana, Nebraska, Texas, and California stations. The Indiana project might at first glance be considered a mere blanket project since, in addition to the general economic studies, it includes nearly a dozen other definite features. However, this apparent excess volume of the project seems to be the result of an analysis of the tractor situation in the State. There is also evidence that the station has recognized the importance of attacking the elements of the tractor problem in the order of their relative importance, in spite of the volume of its project. This is indicated by the studies on such individual subjects as slippage and drive-wheel equipment which has already yielded some significant results. An exhaustive study on this subject was recently completed

in Italy and reported by the International Institute of Agriculture at Rome, thus indicating its importance. Other stations have evinced considerable interest in the subject, as indicated by their inquiries directed to the Research Committee.

While the Nebraska tractor project, operating on State funds, calls for work on tractor testing and rating, and is not considered on the whole as a research project by the Office of Experiment Stations, a large amount of test data have been secured which have been subjected to analysis. Some of these analyses were submitted to the Research Committee for consideration and comment, and it was found that on tentative interpretation they yielded certain more or less new basic relations and principles of a general nature, of course, which, if further investigated, it is believed will materially influence standardization in both the design and rating of tractors. It has been recommended that these analyses be made the basis for the formulation of certain definite research projects on tractors which can not be discussed in detail here. There is every reason to believe that the tractor testing work as now carried on, if properly supplemented by careful and exhaustive analysis, intelligent interpretation, and special investigation where necessary, should be productive of many new basic principles tending to standardize tractor design.

The California project, while somewhat less comprehensive, is organized more specifically upon research lines with certain definite problems in view. Among these, the problem of motor lubrication has received rather exhaustive preliminary analytical study as a subject of prime importance, and provisions have been proposed to carry the work to completion. A further result of the analysis of the tractor problem at the California Station is a project on methods of cleaning the intake air of tractor motors which was submitted to the Research Committee as a study of prime importance. This project has been the subject of considerable discussion by the Committee, and it is hoped that it will serve to standardize all future similar studies.

As a result of an analysis of the tractor problem in Texas, Professor Scoates has proposed a comprehensive project on tractor engine lubrication to the Research Committee as one of prime importance. This involves a co-operative study with the Chemistry Department on motor oils, and is hoped to be put into operation shortly at the station. This project is of considerable interest in view of similar work at the Iowa and California Stations, and the Committee has subjected it to considerable analytical study with a view to making it a standard for similar studies. A striking instance of exhaustive research on this important subject which should be considered in connection with this project has recently been reported by the Lubricants and Lubrication Inquiry Committee of the Advisory Council of the Department of Scientific and Industrial Research of Great Britain. This study dealt with the lubrication of both internal-combustion engines and machinery, and included work with all kinds of lubricating oils comprising both mineral and vegetable oils and mixtures thereof and a number of so-called technical mixtures prepared in the laboratory. Different combinations of gears and gearing were studied. The indications are that for

practical purposes a certain amount of deflocculated graphite in mineral engine oils seems to increase their efficiency. The best manner of incorporation of the graphite is a subject for further study.

No reports of other comprehensive tractor studies at the State stations have been received during the year. It is known that considerable tractor work is being done, but reasonable doubt exists as to the existence of any number of well organized projects of study.

The subject of fuels for internal-combustion engines has commanded considerable attention this year. The fuel studies conducted by the U. S. Bureau of Standards have included such important features as characteristics, economy, and detonation. Significant results as to the relation between the phenomenon of detonation or knock and timing have been obtained. The Engineering Experiment Station of the Ohio State University has also reported studies on the economical utilization of liquid fuel. The fuels section of the Imperial Motor Transport Conference of Great Britain has also conducted some important researches on alcohol as an internal-combustion engine fuel. The work has included especially a comparison of alcohol with gasoline and other volatile hydrocarbons and a study of the effects of mixing alcohol with volatile fuels. The indications are that the lower calorific value of alcohol is almost compensated for by the greater compression at which it can be used, and this property of high ignition temperature under compression is hardly altered by admixture of 20 per cent of benzine or of gasoline itself. The French and Belgian studies of palm oil as a motor fuel in the tropics during the past year are significant and indicate the existence of a new and very effective fuel for tropical use in this relatively cheap and abundant oil.

General tractor studies were conducted during the year in Belgium, France, Sweden, Denmark, South Africa, England, and the colonial possessions and protectorates of Ceylon, Tunis, Java, and India. The Belgian studies were essentially of an economic nature but were planned largely upon the basis of technical considerations. The work in the colonies and protectorates was usually of a special comparative nature and can not be classed as of a very high order of research.

Work along other farm machinery lines has been varied. A project on fertilizer distributing equipment has been inaugurated at the Alabama Station. This seems to have developed into a very important and somewhat pressing problem in some localities. In this connection it is to be noted that the Deutsche Landwirtschafts-Gesellschaft of Germany has recently completed a very exhaustive study of fertilizer distributors under the intensive conditions of cultivation in vogue in Germany. Dust prevention when handling dusty fertilizers was an important feature considered. A significant preliminary finding was that no single machine is available on the market which meets all of the conditions imposed. The work naturally proceeded into an analysis of what a fertilizer distributor should accomplish under such conditions, and on this basis a study was planned and conducted which yielded the basic principles which govern the design and construction of

the fertilizer distributors desired. These are to be placed in the hands of implement manufacturers when the final interpretation is complete. This work indicates the opportunities existing for the development and standardization of machinery of this kind. Thus the possibility is evident that the Alabama project on the subject may be one of far-reaching importance. While its details are not available it is hoped that the plan of procedure has been organized so that the study will not stop with a mere comparison of existing machines.

Studies on the power requirements of farm implements, particularly tillage implements, have been conducted at the New York Cornell, Wisconsin, Nebraska, Montana, Iowa, and Missouri Stations. With one exception, these projects have been operating on research funds and all seem to embody certain research principles. In some cases, notably Iowa, Missouri, and Nebraska, the studies are becoming quite comprehensive. This subject was deemed of such importance by the Nebraska Station that a project on the power requirements of tillage machinery has been submitted to the Research Committee which it is hoped will not only tend to standardize studies of this type but will tend to stabilize and standardize the design of certain tillage machines.

The Iowa Station has a voluminous farm machinery project in force which includes, among other things, studies on corn picker huskers, ensilage harvesters, small threshers, small ensilage cutters, grain shockers, shock movers, and silage packers. To the casual observer it might appear that a great deal of the work under projects of this type would consist merely of miscellaneous testing, and in the past this has probably been true to a considerable extent. But there is now a growing tendency to organize these studies so that on careful analysis the data obtained is susceptible of interpretation which invariably uncovers numerous new and unsuspected basic relations as well as certain misconceptions and omissions. While the work at Iowa on this project, covering so many miscellaneous machinery subjects, has been apparently for the most part conducted on research funds, some of it is believed to be worthy of more careful analysis and planning from the research standpoint than apparently has heretofore been accorded it.

With this in view two projects of proposed research have been submitted to the Research Committee for criticism and comment. One of these is a study of corn planters and corn planting methods adapted to multiple row cultivation, the purpose of which seems to be the development of corn planters and cultivation along efficiency lines. It may be said in this connection that the development of farm machinery along efficiency lines seems to be one of the most popular and pressing subjects in agricultural engineering at this time, especially in the Middle West. The other project submitted to the Committee is on the power requirements of ensilage blowers. An analysis of this project by the Committee showed that the subject includes a number of unsolved and very important problems relating to the efficient use of ensilage blowers.

In this connection a report of similar work conducted at a leading British University was recently presented to the Royal Society of Arts of

Great Britain. The studies dealt specifically with pneumatic elevators in theory and practice, and were limited to suction types. The experiments were conducted with grain, husks, and other materials, and included determinations of pressure of air on grain and other materials; grain velocity, efficiencies of vertical conveyors, and efficiencies of nozzles. Mathematical expressions were derived from the interpretation of the data obtained which express the basic principles and relations governing the design and operation of such elevators. This work should be a valuable aid in work similar to that planned at the Iowa Station.

The work at the National University of Buenos Aires on hay and silage cutters should also be important in this connection. These studies have been conducted for some time with a view to developing the most rational type of knife for hay and silage cutting, and have so far indicated the superiority of spiral-shaped knives to straight knives. The necessity of establishing a definite relation between the geometric form of the knife, a convenient peripheral speed, and the weight of the frame also seems evident. Studies on corn-harvesting machinery at the university have also been in progress, and have resulted in the development of two types adapted for green and dry corn, respectively.

A comparative study of horse and motor cultivation is in progress at the Mississippi Station. While this does not sound like research, it is understood to be operating on research funds, and so must include at least some of the elements of research.

A unique and very interesting project has been apparently finished at the Montana Station, dealing with the development of power by use of bulls in a treadmill. Some of the features of this project, such as the development of an automatic slapper, are very amusing, but yet they involve the use of scientific principles, and the project on the whole seems to be a well-planned and executed piece of cooperative scientific work.

A distinct contribution to the causes of and remedies for thresher explosions has resulted from recent studies by the U. S. Bureau of Chemistry on matters relating to the accumulation and redistribution of static electricity in threshing machines. In all cases a continual marked difference in potential was established between the earth and the different parts of the machines studied. Several steel machines showed, as individual units, a greater potential than the earth. The indications are that under favorable conditions the cylinder concaves and grain pan of a thresher will become electrified to a greater extent than other parts of the machine, resulting in the occurrence of sparks during the restoration of normal static balance.

FARM BUILDINGS.

Considerable work has been reported as being in progress during the year on the subject of farm buildings and equipment, including heating and ventilating. The Iowa and Indiana Stations appear to have been among the leaders in this work as far as amount of work done and number of subjects

studied are concerned. Attention is drawn to this matter since, like the Indiana tractor project, the Iowa and Indiana farm building projects cover a large number of subjects, perhaps too many to be effectively covered in one project. On the other hand, the number of these subjects presented is evidence of the exhaustive analysis which has been made of the subject as a whole, and indicates the growing tendency to select and study the more important elements of the subject revealed by such analysis. The Iowa projects cover such matters as farm houses, general farm barns, cattle barns, dairy barns, horse barns, poultry houses, swine houses, sheep sheds, crop storages, granaries, corn cribs, smoke houses, manure pits, machinery sheds, garages, power plants, cattle feeding barns and equipment, silos, and ventilation systems. The Indiana project is equally as comprehensive. A study of ventilation systems has also been in progress at the Wisconsin, South Dakota, Minnesota, and New Hampshire Stations, and, of course, the classic work on matters relating to ventilation by the late Dr. Armsby and his associates at the Pennsylvania Station is well known to all agricultural engineers. Materials for stable floors have been a subject of special study at the Ohio State University.

Work on silos has also been in progress at the Michigan, Missouri, and Guam Stations. In all three cases the work has been supported by research funds. The investigations at Missouri have been planned to study all conditions affecting the use of the silo, including material of the wall, moisture factors, loss of nutrients, and silo capacities. The Michigan studies have resulted in considerable working data on silo capacities.

The subject of poultry houses has been studied at a number of stations but perhaps most systematically at the Kentucky, New Jersey, Oregon, and Washington Stations. The New Jersey studies have been especially comprehensive and have constituted a process of gradual elimination of different designs down to certain definite standard types and equipment. The work at the Washington Station is also approaching this stage.

Dairy barns and milk houses have received attention at the Wisconsin, Arizona, and Texas Stations. The Wisconsin studies have been quite comprehensive, and the work at Arizona has resulted in the development of an adobe milk house. At South Dakota work on farm barns and dairy barns has been reported which has resulted in quite definite standard principles of design for the State. However, insufficient information is available regarding this work to determine its research status.

A striking piece of research has been reported from the Delaware Station on sweet potato storage houses. Unfortunately it seems that this work was conducted entirely by the Horticultural Division. Nevertheless, it has yielded some valuable basic principles affecting the design of sweet potato storage houses in that locality.

The Minnesota Station has started a study on the heating and ventilating of farm homes. In this connection it is well to draw attention to the fact that noteworthy research has been reported from Germany on the heat conductivity of building and insulating materials and heat permeability fac-

tors of new structures. In addition the University of Illinois Engineering Experiment Station has studied and reported on the emissivity of heat from various surfaces and is continuing the warm-air furnace research work. The Ontario Agricultural College has reported research work on insulating materials, and the American Society of Heating and Ventilating Engineers has reported studies on the transmission of heat through single frame double windows. All of these studies taken together should be of considerable importance in connection with studies of the heating and ventilating of farm buildings and dwellings. The importance of the subject of ventilation needs no emphasis. The Research Committee has made no attempt to formulate a project of research on ventilation owing to the projects already in existence. However, the importance of the subject of the artificial heating of animal shelters has been looked into, and it is hoped that a project may be organized on that subject.

The Committee has considered no general farm building project for a number of reasons. One is that a number of such projects are already in existence. But the most important reason is that the subject obviously first needs a more thorough analysis by all the different States and a comparison of notes to see just what elements should be attacked first.

It would seem that the time is ripe for further studies of farm houses, with particular reference to the development and use of new materials of construction. In this connection it is to be noted that the Ministry of Agriculture of England has inaugurated a set of studies on the relative values of farm houses made of monolithic concrete, cob, pise de terre or earth rammed between movable forms, timber, and timber and brick. The main purpose of this work is the development of the use of pise de terre which promises to be a cheap, flexible, and efficient material.

DRAINAGE.

With certain exceptions it is not believed that the drainage work which has been done at the State stations this year as a whole has been of a very high order of research. Of course, the very nature of the subject and general circumstances make it difficult to plan and carry through projects of research. The demand for practical information on the subject seems, however, to have occupied a large part of the time of the men assigned to such work at the stations, and has left relatively little time and funds for research.

In spite of circumstances and conditions tending to discourage research some few noteworthy pieces of work have been done. The cooperative projects in North Carolina on the efficiency of underdrains, run-off from drainage canals, run-off from underdrained land, and action of tile drains on ground water level deserve special mention. These studies seem to have included a special study of soils as a basis for the drainage experiments. Another noteworthy cooperative study is that conducted at the Alabama Station on the effect of tile drains in the lime or prairie soils. Two other local cooperative projects have also been inaugurated at the Alabama Station on

farm drainage and terracing and studies of swamp and overflow conditions. The nature of these studies is not yet available. The Ohio and Minnesota Stations are engaged in studies of the depth and spacing of drains, and an interesting study on this subject has just been reported from Germany.

At the Montana Station a study is reported as being in progress on different drainage practices followed in the State and their relative effectiveness. This is hardly research, but could be made the basis for such work. The Colorado Station seems to be continuing its studies of drainage requirements of crops.

The Oregon Station has several projects on the drainage and improvement of wet lands, including "white" lands, greasewood lands, and tide lands. Much of this work involves the removal of excess alkali and the restoration of a fertile structure. Considerable basic data have already been made available from this work. At the California Station work is in progress on land drainage by pumping and on the reclamation of certain marsh and alkali lands by drainage.

Work on the drainage of peat and muck soils has been reported from Wisconsin, Minnesota, and Florida. The Wisconsin Station has been especially active in this respect. An important feature of this work is the fact established that the settlement of drained peat soils must be considered as an important factor in the design of both tile and open drains. The further reclamation of these soils after drainage is an important complication of this work.

Studies on the cost of trenching, hauling, and laying tile have been reported from Ohio. The Minnesota Station has started a correlation of land and crop values with cost of drainage, and has a project in operation on the movement of water in soils. The Kentucky Station is engaged in studies of the effect of the initial moisture present on the movement of water in soil. The project at the Missouri Station on the investigation of water penetration, evaporation, run-off, and erosion in average Missouri soils should also be mentioned.

Before leaving the subject of drainage, attention should be drawn to a recent study conducted by the Ministry of Agriculture of England on mechanical ditchers for land drainage. The studies so far have been conducted only on a rotating wheel tractor ditcher for digging tile trenches. The significant fact was established that there is little difference between the cost of work by this machine and by hand labor. However, other advantages such as quick completion of work enter in which establish the importance of mechanical ditchers. Work by the Ohio Station on the other hand has so far indicated a considerable saving by machine trenching. The same result was obtained in experiments conducted for one year by the North Scotland Agricultural College.

IRRIGATION.

The subject of irrigation is one in which considerable work has been in progress. It has perhaps received more intensive research treatment than any other division of agricultural engineering, and apparently conditions and circumstances have been distinctly favorable for such work. Under the able leadership of the Irrigation Investigations Office of the U. S. Department of Agriculture the work has developed throughout the irrigated West, and the cooperative projects and individual State projects which have been reported in progress are numerous. The majority of these projects have been operating on research funds, which is a very significant fact in itself when considering their research status.

Owing to the large number of such projects in existence of about equal importance, it would be impracticable to attempt to give them any comprehensive review here. However, the California Station submitted a very comprehensive project to the Research Committee for consideration on the relation between irrigation head, soil type, and grade in the preparation of land for irrigation, to be conducted at the station. This general subject is already being studied in one form or another at a number of the stations, and seems to be a very important irrigation matter at this time. The Idaho and Oregon Stations especially have been interested in such work, as has also the Office of Western Irrigation Agriculture of the U. S. Department of Agriculture. It was with the object of attempting to standardize this particular type of study that the project in question was so readily considered by the Committee. It is hoped to make this project somewhat of a standard pattern for such work, although it is realized that this will take time and considerable analytical study.

Attention may also well be drawn to the ground water studies at the Montana, Arizona, Utah, and New Mexico Stations, and to the pump irrigation studies at the Nebraska, Montana, Arizona, and Utah Stations. The work at the Nebraska, Arizona, and Montana Stations, especially on pump irrigation, has been productive of considerable basic working information.

The question of duty of water has been under investigation at the Utah, Idaho, California, New Mexico, Oregon, Montana, and Nebraska Stations, especially, and this work is so well known as to need no comment. The U. S. Reclamation Service has also been quite active in this connection.

Numerous alkali land and alkali tolerance studies have also been in progress, notably at the Arizona, California, New Mexico, Idaho, and Utah Stations, and the U. S. Department of Agriculture has reported a comprehensive study on the quality of irrigation water in relation to land reclamation. A significant conclusion drawn from this study was that the quality of irrigation water should be judged not only by considering the total quantity of the salts in solution or the proportions of the acid radicals but also the proportion of the sodium to the calcium and magnesium. This is taken to indicate that water to be safe for long-continued irrigation should be relatively rich in calcium and magnesium.

The study of water measurement devices, including current meters and the Venturi flume, at the Colorado Station and of weirs at the Montana Station should be mentioned, and the evaporation studies at Colorado are reported as being still in operation. Other special studies related to irrigation which have been reported are on the use of concrete pipe in irrigation by the U. S. Department of Agriculture and on conveyance losses of water on irrigation projects by the U. S. Reclamation Service. The latter study has indicated that 25 per cent is about the minimum loss that may safely be estimated under favorable conditions and that 50 per cent is sufficiently high for the average well planned project. It was further shown that concrete linings, on account of their high costs, should be resorted to only after all other means of preventing losses have failed.

Noteworthy foreign work has been reported by the Deutsche Landwirtschafts-Gesellschaft on the spraying of fields with municipal sewage. This work has led to the development of three different types of portable spray irrigation apparatus which may be used in the distribution of clarified and partially clarified municipal sewage, especially in furrow irrigation.

FARM WATER SUPPLY AND SEWAGE DISPOSAL.

Research on the subjects of farm water supply and sewage disposal has apparently been almost nonexistent during the year according to the information available. There are a few exceptional cases which will be mentioned, but it is believed that the majority of such work that has been done during the year has consisted largely of reproduction and very little of creation. There is ample evidence of the importance of unearthing and establishing some of the basic principles of this subject. The Research Committee hoped to formulate a project of research on some phase of it but has failed to do so.

There have been many more or less well meaning but poorly planned and conducted attempts to get at the fundamentals of the subject. There are a few exceptions, however, which may well be mentioned. The study at the New Jersey Station on the biology of sewage disposal is unique and stands practically alone in its class as a research project on farm sewage disposal. Its purpose is to determine how sewage may be disposed of with a reduced amount of water and end-products containing waste materials in a commercial form. Here would appear to be a wonderful opportunity for cooperative work on an extremely important subject. In a preliminary study of the biology of the sprinkling sewage filter, it has been found that organisms are present in the gelatinous film of a filter which are similar to those occurring in the soil, and which act in the oxidation of organic nitrogen to inorganic forms. This process seems to be a gradual one, starting in the top layer with the zone of greatest activity in the second layer. Here it seems is a distinct step forward to establish a bridge between the results obtained with large-scale filters and the results desired on small-scale absorption or filter systems. Other biochemical facts were established which should be of the utmost importance in a study of farm sewage disposal.

The work at the Montana Station on farm sewage disposal in which at least three methods are being studied is perhaps not so comprehensive in plan as the New Jersey project, but is a more distinctly engineering project. This project has been quite productive of information so far, but it is believed it should be continued to a point where interpretation of the data obtained will yield some definite basic principles. It also is believed that a certain amount of cooperation with the Chemistry Department would add materially to the value of this project. The work at the New York Cornell Station on the disposal of creamery sewage and the disposal of domestic sewage by subsurface irrigation should also be mentioned. The latter of these projects apparently has been in operation for some time. The Missouri Station has for some time been conducting a project on sanitary equipment for farm homes in which unfortunately it would seem the extension features are apparently being considered at the same time.

The U. S. Public Health Service has had a most comprehensive project in operation for some time on the treatment and disposal of creamery wastes. This has been conducted in cooperation with the U. S. Department of Agriculture. The interpretation of results obtained has established numerous basic principles of value. The work at the Minnesota Station on farm sewage disposal should also be mentioned. This work indicates the superiority of the rectangular, two-chamber septic tank for certain Minnesota conditions.

The Rothamsted Experimental Station in England has recently reported a remarkable piece of research on the use of straw filters for sewage purification. The indications are that straw when used as a filter gradually removes the nitrogen from the sewage and, as the filter ripens, a straw manure is formed equal in value to the best stable manure. At the same time the sewage is effectively purified. It is concluded that for best results about 2 lbs. of dry straw per person per day is required in the filter. From 20 to 35 days is required for maturity of the straw filter.

Both the Idaho and North Dakota Stations have water supply projects. The former consists of a study of the design and installation of farm water supply systems, and does not give outward evidence of carrying the aspects of true research. The latter, however, is a Hatch fund project to determine the suitability of North Dakota waters for drinking and mechanical purposes, and unfortunately is confined to the Division of Agricultural Chemistry.

There are probably other water supply and sewage disposal studies in operation, but these are all which have been reported. It is believed that the time is ripe to get together on this subject with a view to digging out the basic principles involved. It is recommended that future research committees get into touch with the Montana, New York Cornell, and New Jersey Stations, the U. S. Public Health Service, and other institutions interested in the subject, with a view to establishing some studies on this subject which will settle the questions relating thereto once and for all.

LAND CLEARING.

While the subject of land clearing is an old one, it has developed some new and interesting aspects during the past two or three years, and especially since the signing of the Armistice ending the World War. The U. S. Department of Agriculture has shown its interest in the subject by conducting cooperative experiments with the Wisconsin Station on the use of explosives in blasting stumps. Salvaged T.N.T. and picric acid have developed into effective explosives for this purpose, as indicated by the Wisconsin experiments. So-called grenade powder and modified versions thereof have also been used with a certain degree of success. The Wisconsin Station has also conducted studies on the time of brushing and seeding cut-over land, on the comparative strengths of dynamite required for blasting pine and hardwood stumps on various soil types, and on the comparative value of the different methods employed in the removal of pine and hardwood stumps. A certain amount of similar work has been in progress at the Minnesota, Oregon, and Alabama Stations. Of course, a large part of this work consists mainly of comparative experiments. Yet the results are to a certain extent susceptible of analysis and interpretation into basic principles and apparently little more can be asked in view of the nature of the work. The work has resulted in the development of new and improved methods, and it is believed that it can well be carried much further.

MATERIALS OF CONSTRUCTION.

Materials of construction as a subject has developed from a minor miscellaneous matter to one of the main divisions of agricultural engineering. Its connection with all other important divisions of agricultural engineering is becoming more and more evident, and its rise to an important division is only a natural result and true indication of progress in the subject as a whole. The preservative treatment of fence posts, timbers, lumber, shingles, and other wooden structural materials has been under investigation at the Alabama, Minnesota, Montana, and Iowa Stations especially. The U. S. Department of Agriculture has reported a study on powder post damage to timber and wood products and preventive measures. These have indicated the effectiveness of kerosene and hot boiled linseed oil as preventive measures against this destructive agency. The American Wood Preservers' Association has derived mathematical formulas showing the penetration of creosote into various sizes of sawed and round timbers, and the German Agricultural Society has conducted an investigation of the fundamental principles of wood conservation in order to get at the root of the matter.

The Minnesota Station has reported a comparative study of fence posts and an investigation into the effect of structure, time of cutting, and methods of seasoning of white cedar on the penetration of preservatives. The Ohio Station is also engaged in an investigation of the relative durability of fence post timbers, and the Iowa Station apparently is continuing its project on roofing materials.

A study has been in progress at the New Jersey Station on fungi injurious to paint. In this work the purpose is to determine the species of

fungi growing on painted surfaces, the environmental facts and conditions, the injurious effects, the relationship of fungi to paints of different composition, and preventive measures. This is a new and unique study, and would seem to be an outgrowth from or an advance on the comprehensive studies of paints and painting conducted for some years by the North Dakota Station and the U. S. Bureau of Standards. The U. S. Reclamation Service has also been engaged in a study of water gas and coal-gas-tar paints for irrigation structures which indicate the superiority of tar paint for submerged metal works.

The Iowa Station has been conducting a service study of oils, presumably lubricating oils. The Idaho and Wisconsin Stations have studied the design, manufacture, and durability of concrete tile for drainage and irrigation purposes, and the Wyoming Station is apparently still engaged in its study on the alkali proofing and the preparation of alkali-proof cements. The cooperative project on the action of alkali on concrete conducted by the U. S. Department of Agriculture, the U. S. Bureau of Standards, and the U. S. Reclamation Service is apparently still in existence. All of these studies seem to indicate that the sulphates are the salts most dangerous to concrete.

The U. S. Department of Agriculture has recently been engaged on a study of the water resistance of treated canvas during continuous exposure to weather. Eighteen different treatments have been tested. The effectiveness of lead oleate and Bermudez asphalt in waterproofing mixtures has been especially indicated. Beeswax is superior to all other hard waxes tested.

The University of Illinois Engineering Experiment Station has reported a study on the thermal conductivity and diffusivity of concrete, indicating the relation between the conductivity and the proportion of solid material to voids. The Lewis Institute has also reported a study of much interest to agricultural engineers on the effect of storage of cement. Another general study and summary of data is that made by the U. S. Bureau of Standards on strengths and related properties of metals and certain other engineering materials. This work should be of special interest in connection with the development of farm machinery and motors.

MISCELLANEOUS.

As usual there are a few miscellaneous features of agricultural engineering under study which deserve mention. The Alabama Station has a project on destructive distillation and one on the effect of grade of terrace and its relation to soil type. The Illinois and Missouri Stations and the Ohio State University are also studying the subject of soil erosion and preventive measures. The work at Ohio has recently been centered on such special features as broad base terraces and earth-saving dams. In this connection attention should be directed to a project in soil erosion and preventive measures submitted by the Nebraska Station to the Research Committee for consideration. While this project in its original shape was not considered to be research by the Committee, sufficient comment and suggestions

were made to serve as a basis for the standardization of projects of this kind. It is believed that soil erosion and terracing studies should be placed upon a definite standard basis with reference to soil type and other conditions, so as to make aimless testing in the subject unnecessary. The importance of the subject needs no emphasis.

Both the Minnesota and Michigan Stations have started work on small farm electric light plants. While the status of this work is difficult to determine, it is noticed that the Michigan Station has made a brief analysis of the costs which enter into the production of electrical current by gasoline or kerosene. The Ohio State University is also engaged in a study of the effect of oil on the operation of farm electric plants.

Tillage and tillage methods are subjects normally related to the work of agronomists. However, they have such a distinct relation to the development of tillage machinery that it is considered advisable to include them as miscellaneous agricultural engineering matters which are at least of a cooperative nature. In fact, certain cooperative projects are in existence. Studies of tillage and tillage methods have been reported from the South Dakota, North Dakota, North Carolina, Oklahoma, Illinois, Oregon, New York Cornell, South Carolina, Indiana, and Ohio Stations. In nearly every case the main point under study is that of depth of tillage. Moisture content seems to be second in importance. The Ohio and North Dakota studies seem to have been especially comprehensive, and the question of subsoiling has been given considerable attention in both projects. The North Dakota results so far are not favorable to the general practice of subsoiling. Recent German experiments on the influence of water content and void space on the ease with which soil may be cultivated have indicated that the common soils are most easily cultivated when they contain hygroscopic moisture only, and that this condition is apparently independent of other physical characteristics. This study would seem to be of particular significance when considering such matters as draft and scouring.

A very important miscellaneous subject which is being studied by the U. S. Department of Agriculture is that of dust explosions. This work, much of which is being conducted in cooperation with the U. S. Bureau of Mines, has yielded some very significant results of far-reaching importance. While it is not practicable to review all these studies here, it is believed that this subject is one to which all agricultural engineers should devote some attention, owing to its close relation to the design of farm structures.

The Research Committee has had a miscellaneous project under consideration, submitted by the Iowa Station, on methods of multiple hitching of horses. This will be a cooperative project with the Animal Husbandry Division. The difficulty of developing a research project on such a subject is obvious, but the purpose is to inject some engineering into multiple hitching and to try to establish some working principles.

CONCLUSION.

From this summary and from the survey made by the Research Committee during the year, four general subjects seem to stand out from the rest as being of prime importance and worthy of immediate and exhaustive research treatment. These are in the order of their importance, as indicated by the survey: (1) Power requirements of farm machinery and its more efficient utilization, (2) farm water supply and sewage disposal, (3) increase of economic efficiency of horse and mechanical power, and (4) determination of standards of design and performance for farm machines and parts thereof.

These four general subjects represent the consensus of opinion of agricultural engineers over the country and more particularly throughout the Middle West. Of course each of these subjects involves a number of important problems which on analysis should unfold an extensive program for research. It is recommended that these serve as a basis for the operations of the Research Committee for next year.